



No. 2005–43

**ENTREPRENEURIAL ROLES ALONG A CYCLE OF
DISCOVERY**

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February 2005

ISSN 0924-7815

Entrepreneurial roles along a cycle of discovery

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Abstract

The literature on entrepreneurship recognizes a variety of entrepreneurial roles, and the question arises what roles are played when and by whom. In this article, roles are attributed to different stages of innovation and organizational development. A central theme is the relation between discontinuity, in radical innovation (exploration), and continuity, in application, diffusion and adaptation (exploitation). Use is made of a concept of a 'cycle of discovery', which seeks to explain how exploration leads on to exploitation, and how exploitation may yield exploration, in a step-by-step development towards radical innovation. Parallel to this there are processes of organisational development.

Key words: entrepreneurship, innovation, discovery, organizational learning

JEL classification: D83, M13

Introduction

In the history of economics one finds a variety of notions of entrepreneurship, proposed by a variety of classical and Austrian economists: Adam Smith, Marshall, Cantillon, Say, Bentham, Thünen, Mangoldt, Menger, von Mises, von Hayek and, later, Kirzner. In more recent literature, discussions and surveys have been provided by, among others, Kets de Vries (1977), Stanworth & Curran (1973), Scase & Goffee (1980), Casson (1982), Hébert & Link (1982), Chell (1985), Weinberg (1990), Chell et.al. (1991), Nooteboom (1994), Thurik (1996), van Praag (1996), and Blaug (1997). The following entrepreneurial roles have been identified:

- innovation (Bentham, Thünen, Schumpeter and perhaps Say)
- creative destruction by novel combinations (Schumpeter)
- arbitrage: the identification and utilization of opportunities for matching supply and demand (Cantillon, Smith, Menger, Mises, Hayek, Kirzner)
- the provision of capital (Marshall)
- creating or entering new markets (Mangoldt, Schumpeter)
- the configuration and management of production factors for efficient production (Say, Marshall, Mises)

It has been argued that the provision of capital is not part of entrepreneurship, since capital can be obtained from capital markets, and that management is not part of it, since that can be hired (Blaug, 1996). However, in view of the 'real', Knightian uncertainty involved in entrepreneurship, and the idiosyncrasy of perception and initiative that characterize entrepreneurship, outside supply of capital can be problematic, so that the entrepreneur has to supply his own at least in part (Casson, 1982). Management is not routine, certainly in the early

stages of exploring Schumpeterian novel combinations, where the entrepreneur has to supply his own leadership and management. In this article it will be argued that the later development and adaptation of organization also constitute a non-trivial entrepreneurial task. So, it seems that the provision of capital and management are still part of an entrepreneurial process. A key question is how 'episodic' change, in Schumpeterian 'creative destruction', is related to more gradual change, in incremental innovation and in the arbitrage function of entrepreneurship.

Associated with different roles of entrepreneurs, different characteristics and competencies have been identified, as follows:

- acceptance of ('real') uncertainty (Knight, Schumpeter)
- alertness, perceptiveness, open-mindedness, imagination, vision, idiosyncratic perception and initiative (Kirzner), independence (Schumpeter), internal 'locus of control' (an attitude that one is not at the mercy of external change but can influence the environment)
- judgement, sense of realism, decisiveness
- perseverance, ambition or need for achievement
- charisma, strength of personality; capability of leadership (Schumpeter), managerial capability (Marshall)

According to Schumpeter entrepreneurs form an elite, while according to (other) Austrian theorists (especially von Mises) entrepreneurship is widely dispersed. The need for charisma is related to radical (Knightian) uncertainty. Engaged in radically novel ideas, for markets that do not yet exist, the entrepreneur needs to be able to inspire followers, partners, employees and providers of capital, to carry them along in a risky venture with unknowable outcomes.

A complication, in the definition of entrepreneurship, is that often (especially in the construction of statistics) entrepreneurship is taken as synonymous with self-employment, in small and medium-sized enterprise (SME). The literature has recognised a variety of motives and conditions for self-employment, as follows:

'Push' factors (self-employment as a need):

- social maladjustment, inability to accept authority, heterodoxy (Kets de Vries, 1977)
- conditions of unemployment, inability to access labour markets due to ethnic or religious discrimination, lack of social security benefits for unemployment and old age (the hypothesis of a 'flight' into self-employment, Stanworth & Curran, 1973; Scase & Goffee, 1980)
- personal crisis that triggers a switch in the course of life (illness, bereavement, identity crisis) (Chell et al. 1985)
- pressure to take over father's firm

'Pull' factors (self-employment as an attraction):

- ambition, will towards self-realization, creativity, power, or wealth
- opportunity: offer from a friend or family member to participate in his venture, availability of finance (e.g. from family), chance access to assets or markets
- wish to be independent, or to maintain a small scale, personalized form of business or a traditional craft

According to some estimates, only between 10 and 20% of self-employed are of the heroic, Schumpeterian type of entrepreneurship (Williams, 1977; van den Tillaart et. al., 1983). The rest, then, are driven by one or more of the other motives. Motives arise from personal inclinations and experience, in combination with institutional conditions. For example, in less developed countries there may be more unemployment and there is less social security, which engenders the push factor of flight from unemployment, in the search for alternative means of caring for family. In some countries there is more ethnic and religious discrimination in labour markets than in others. In more developed countries, on the other hand, with benefits for unemployment and old age, pull factors of self-realization are more prominent. Attitudes to risk vary across cultures. Clearly, the emergence and survival of small, independent ventures depends on conditions of technology (effects of scale) and market (entry barriers, intensity of price competition). In small business, there is room for a variety of motives, due to funding by banks or venture capitalists or from informal, family-based sources, which impose less strict and uniform norms of performance than share markets do.

All the motives indicated have been found in a variety of empirical research. Here only a small, illustrative sample can be given. In an international comparative study of 2500 entrepreneurs in nine countries, Pompe et. al. (1986) found that in highly developed European countries (UK, Germany, Netherlands) and Japan more than half of self-employed were motivated by self-realization, compared to around 10% in lesser developed countries (Cameroon, Colombia, Brazil, and Indonesia). Dissatisfaction with employment occurred more in Europe than in lesser developed countries outside Europe.

This article addresses the question how we may connect these widely diverging roles, characteristics and motives of entrepreneurship. Do the different types of activity have to be combined at the same time, or are they required at different times, in some development process, by different people perhaps? The aim is to frame entrepreneurship in terms of a Hayekian discovery process in markets. The article proceeds as follows. It starts with a first identification of different stages of innovation and organizational development. Second, it discusses the central theme of continuity and discontinuity in change. Third, it summarizes a 'cycle of discovery' that argues how there may be continuity in discontinuity. Fourth, it uses the cycle to re-formulate different features of entrepreneurship in relation to different stages of development.

Transitions and complementarities

Concerning the more innovation oriented entrepreneur (creative destruction), Schumpeter (1909, 1939, 1943) recognized two types. According to him, in early capitalism the innovative entrepreneur ('Mark I') was an independent outsider, setting up his own new venture, without vested interests in established technologies, products and markets. In later capitalism, entrepreneurship ('Mark II') increasingly required large teams of specialists that only larger firms could afford. Therefore, a second question, which this article aims to answer, is how aspects of innovation and diffusion are related to firm size and other firm characteristics. Rothwell (1985, 1986, 1989) proposed that both types of entrepreneurship (Mark I and II) have a role to play, and that there is 'dynamic complementarity' between small and large firms, in innovation, with small and large firms being strong and weak in opposite ways. Small firms have 'behavioural' advantages: motivation to accept risks and low income in early stages of innovation, close contact with customers and employees, flexibility of small emergent firms that haven't yet hardened into organizational shapes to fit established, 'dominant' practices. Large firms have advantages in resources: revenues from established activities to fund innovation, a wider range of activities to pool risks and cross-subsidize new ventures, specialised human and

other resources, market access (distribution channels and brand names), and established political and social capital.

In organizational development, successful new, small firms encounter growth obstacles (Bennis, 1969; Greiner, 1972). At first, in a new entrepreneurial venture, the entrepreneur participates in shop-floor activities and customer contacts, and coordinates on the basis of direct supervision, in a simple organizational structure (Mintzberg, 1983). In view of this, knowledge does not need to be highly codified. As success emerges and sales volume grows, the distance between the entrepreneur and operational activities increases, and the entrepreneur must institute division of labour, specialized support and staff functions, and codified, formalized procedures of coordination and control across spatially and functionally separated activities. In other words, in the development of the firm there is the need of a transition from Schumpeterian to Marshallian entrepreneurship. Failing to see this, or to accept it and make room for managers, many entrepreneurs fail to make the transition.

In view of dynamic complementarity, one would expect that large firms typically produce the scientific inventions that require large R&D teams with specialists, while small, outside firms will be quicker in bringing inventions into practice, in new products (exploration), and large firms carry new products into efficient, large-scale exploitation. Clearly, the division of labour between small and large firms depends on institutional conditions, such as limits in the integration of activities in large conglomerate firms imposed by anti-trust policy (Nelson, 1993).

The analysis is borne out by many empirical studies (e.g. Blair, 1972; Davis et. al., 1985; Wyatt, 1985; Wijnberg, 1990; Acs & Audretsch, 1990). Examples of inventions that were developed and commercialized by small firms are: electric light (Edison), the telephone (Alexander Graham Bell), aeroplanes (Wright brothers), micro-computers (Silicon Valley), self-service retailing (Nooteboom 1984), and computer-aided design (Rothwell & Zegveld 1985).

This article builds on the notion of exploration and exploitation, derived from Holland (1975) and March (1991). In order to survive in the short term, firms must efficiently exploit current resources (assets, capabilities, and competencies). In order to survive in the long term they must develop new resources. Thus, to survive now and later, they need to combine exploitation and exploration, either within the firm or in networks of firms. That is a paradoxical task. Exploitation typically requires division of labour, which requires stable roles and standards, and absence of ambiguity, while exploration requires a break-up or shift in those dimensions of organization. According to the principle of dynamic complementarity, small firms have a comparative advantage in exploration, and large firms in exploitation. Exploration requires more acceptance of uncertainty and lack of resources, perseverance, and charisma to carry others along in that uncertainty, and flexibility to deal with emerging novelty. Exploitation requires the massing, matching and managing of diverse resources. Dynamic complementarity, then, may take several forms:

- Small firms pass on the results from exploration to large firms, for the sake of exploitation. This is observed, for example, in the transfer of pharmaceutical innovations from small biotech firms to large pharmaceutical firms.
- After exploration, small new firms grow into large ones, overcoming the obstacles involved, to achieve the advantages of size needed for exploitation. An example is Apple computers.
- After exploration, small firms that fail to overcome growth obstacles are taken over by large firms. This is a classic form, with many examples.
- The innovations of small firms are imitated by large ones, which then slowly push out the smaller, less efficient firms, due to economies of scale. An example is self-service retailing, which in most countries was initiated by small, independent firms (with the

exception of Switzerland), followed by large, integrated chain store firms, to which the small independents tried to respond with forms of collaboration (buying cooperatives, voluntary chains, and franchising, cf. Nooteboom, 1984).

The case of retailing illustrates a well known point that small firms may, at least to some extent, compensate for their lack of resources by collaboration, in networks (Johannisson, 1986), to establish scale, specialization, diversification of risk, and market access. The need for personalized networks depends, among other things, on lack of institutions, such as a reliable legal system. Birley et. al. (1991) showed that in Italy a relatively large amount of time is spent in building and maintaining networks. Conversely, large firms may compensate their disadvantage of sluggishness by allowing for more or less autonomous or modular units, for the sake of exploration. Thus, the notion of dynamic complementarity shifts from that between small and large firms to that between more or less integrated organizational forms, within and between firms.

Here, we find the beginning of an analysis that assigns different features of entrepreneurship to different stages of development, in innovation and organization. However, the distinction between exploration and exploitation is too stark. Between radical, frame-breaking innovations and mere application, there are incremental innovations, and shifts of innovation from products to production and organization.

Continuity and discontinuity

A central theme, in the literatures on innovation, entrepreneurship and organizational change, is that of continuous versus discontinuous change. In the literature on organizational change, Weick & Quinn (1999) proposed that there are two distinct traditions: one that takes change as discontinuous or 'episodic', and one that takes change as continuous and cumulative. Purportedly, episodic change breaks the inertia of established practices and structures, is caused by external shocks, and proceeds according to managerial design and planning. Continuous change, by contrast, arises from an accumulation of small changes, in a 'redirection of what is already under way' (Weick & Quinn, 1999, p. 366), and is emergent rather than planned. Episodic and continuous changes are presented as alternatives, and no clue is given of how they might be connected.

An episodic view is presented in the notion of 'punctuated equilibria' (Tushman & Romanelli, 1985; Tushman & Anderson, 1986; Romanelli & Tushman, 1994; Gersick, 1991). Here, long periods of stability, on the basis of existing 'dominant designs' (Abernathy & Utterback, 1978), are punctuated only intermittently by radical breakthroughs. No explanation is given of the origin of such breakthroughs. Are they created out of nothing, or do they emerge, somehow, from experience?

Similarly, in the economic literature on innovation and entrepreneurship, (neo)Schumpeterian innovation theory is clearly episodic: inventions, which remain unexplained, creatively destroy established order, and then converge on dominant designs that form the basis for a newly developing practice. Related to this, in evolutionary theory (Nelson & Winter, 1982) the creation of variety by invention is seen as analogous to mutations in biological evolution, yielding novel forms that are subjected to selection in markets, with surviving innovations propagated by growth and imitation. As in Schumpeterian theory, evolutionary economics offers no explanation of the origins of invention.

Nevertheless, a great advantage of evolutionary theory is that it offers an approach to the development of new forms that is not based on design and planning, in contrast with views on episodic change, in (even recent) management literature (cf. Weick & Quinn, 1999,

referred to above), as somehow designed ‘from above’, by management, under pressure from exogenous shocks that remain unexplained. Furthermore, also unlike the management literature (Tushman, Romanelli, Anderson, and Gersick, referred to above), in evolutionary biology Eldredge & Gould (1972) and Gould (1989) offered at least the beginning of an explanation of episodic change, in the form of punctuated equilibria, on the basis of ‘allopatric speciation’. There, the origin of new species is attributed to a long process outside of, or at the margin of, parent niches, where there are opportunities for experimentation with novel forms without their being swamped by the dominant species in the parent niche. Punctuation is rare, relative to long periods of stability, because it takes a long process of extraneous trial and error to establish a new form that is strong enough to successfully invade the parent niche. This point of evolutionary ‘logic’ is incorporated in the ‘cycle of discovery’ that will be used in this article.

However, while evolutionary theory has generated important perspectives, the evolutionary metaphor remains misleading (Nooteboom, 2001). It draws attention to selection, to the neglect of the origin of novelty, since in biology that is random, and there seems little to say about it. However, in economic systems the generation of variety by invention arises from human and social processes of learning, based on experience and interaction, in which there is less randomness and more system than in the mutation of genes and the cross-over of chromosomes. Secondly, the selection environment of markets and institutions is subject to shifts as a result of entrepreneurial and political action. This yields forms of co-evolution of the units of selection and the selection environment that go far beyond what is conceivable in biology. Thirdly, transmission is based on growth of firms, imitation, training/education and communication, which are of a different order entirely from the transmission of genes.

The entrepreneur according to Schumpeter has variously been characterized as being non-adaptive, causing disequilibrium, in creative destruction, and yielding increased uncertainty in markets (Cheah & Robertson, 1992). The entrepreneur according to (other) Austrians (Menger, Hayek and more recently Kirzner, 1973, 1985) is adaptive, reacting to exogenous shocks of change, utilising inventions and drawing markets towards equilibrium in the sense of diffusing innovations and matching supply and demand. Here again, we find the split between episodic and continuous change. Consider the following quote (Kirzner, 1973, p. 127) ‘For Schumpeter the entrepreneur is the disruptive, disequilibrating force that dislodges the market from the somnolence of equilibrium; for us the entrepreneur is the equilibrating force whose activity responds to the existing tensions and provides those corrections for which the unexploited opportunities have been crying out’. In this arbitrage view of entrepreneurship Kirzner is close to Cantillon. While Kirzner's entrepreneur is more ‘alert’ to new possibilities than other people, this is ‘... not really a theory about how agents create new data, but how they react to new data’ (Foss, 1994, p. 111). The question is how entrepreneurial action can also yield ‘new data’: how entrepreneurs can break through existing categorical imperatives.

However, like the distinction between exploration and exploitation, the distinction between Schumpeterian, disequilibrating, and Smithian/Austrian, equilibrating entrepreneurship is too stark. There are cases of entrepreneurship that are difficult to assign to either type, because they contain elements of both. An important type of innovation, between Schumpeterian entrepreneurship and entrepreneurship according to (other) Austrians, is product differentiation. It can be reconstructed as bridging gaps between supply and demand in Lancasterian product characteristics space (Lancaster, 1966), by offering novel combinations of available product characteristics that are closer to pockets of demand. This is Austrian in that no new characteristic appears, and gaps are bridged in characteristics space by varying the intensities of characteristics in their mix. Differentiation becomes more Schumpeterian when it consists of the addition of a new dimension to characteristics space, which subjects user preferences and the positioning of

existing products to a jolt (Péli & Nooteboom, 1999). An example would be adding colour to toothpaste, which used to be uniformly white, or to cars, which according to the famous dictum of Henry Ford used to be available only in black. Another example of an innovation that contains elements of both Schumpeterian and Kirznerian entrepreneurship is the example of railroads discussed by Schumpeter (1939). Uncertainty is reduced as railroads diffuse, and entrepreneurship in this area becomes increasingly routine. But now consider the ‘ice station’ innovation of beer brewer Annheuser Bush (AB). By combining railroad transportation with the cooling of beer by means of ‘ice stations’, AB greatly extended the feasible distance between market and production, thereby allowing for economies of scale in brewing. This innovation that may seem Schumpeterian was produced as a combination of well diffused, settled technologies of railroads and cooling, in an identification of possibilities from existing technology and practice that might as well be seen as Kirznerian.

Note also that diffusion does not consist in a simple mechanical ‘working out’ of a single innovation. Generally, new applications require adjustment or ‘re-invention’. Often, new applications are achieved in combination with complementary innovations in technology, marketing, organization, infrastructure and institutional conditions. Different firms have different, partly firm-specific constellations of resources, partly embedded in teams, organizational structure and culture, where adoption of innovation is seldom a mere slotting in, and typically requires a reconstruction of existing structure, process and culture. What is established on an industry level may require quite fundamental shifts on the firm level. That is why in the measurement of innovation a distinction is made between products or processes new for the world, for an industry and for a firm. In short: diffusion requires innovation on the part of users.

In the literatures of innovation and organization, there is ample empirical evidence of apparently discontinuous breakthroughs and ruptures, pleading for the episodic view of change (Tushman & Anderson, 1986). The question now is how discontinuity arises, on what basis, and whether there might be continuity in it, or at least intermediate steps or stages. Breakthroughs and inventions must arise, somehow, from experience and learning. How does this work? Or, in other words, how does exploration arise from exploitation? Answers are sought from a theory that proposes different stages in a ‘cycle of discovery’ (Nooteboom, 1999, 2000).ⁱ One may think that such a theory of discovery is logically impossible, since it would entail the prediction of discovery, and if discovery could be predicted it would no longer constitute discovery. But this is mistaken: we may well be able to specify processes of discovery without thereby claiming to be able to predict its outcomes.

Cycle of discovery

The cycle of discovery used here is based on a heuristic that indicates how there may be continuity in discontinuity, and how exploration may emerge from exploitation. The term ‘heuristic’ is used, rather than the term ‘logic’ of discovery, since it does not represent an inexorable sequencing of steps, but a procedure that will generally work, while being subject to many contingencies, and allowing for exceptions. The heuristic consists of several stages succeeding each other in an ongoing cycle. Here, a brief summary is given, and in later sections the stages will be discussed in more detail.

First, to start somewhere on the circle, there is a process in which radical novelty ‘works out’ into the emergence of a ‘dominant design’ (Abernathy & Utterback, 1978) or ‘technological regime’ (Teece 1988), here called ‘consolidation’, which yields a basis for efficient exploitation, as recognised in the innovation literature. In that literature, it has been proposed that first technology converges on a technical dominant design, with competition focused on technical

feasibility and market acceptance. In the convergence of a variety of prototypes on a dominant design there is ‘reduction of content’. Patents wear out, market uncertainty decreases, and demand for the emerging standard increases. The competencies involved in the new technology and product become more determinate, less tacit and more codified, thus becoming more imitable. Imitation and new market entry arise, and increased competition exerts pressure to produce more efficiently, by utilizing economies of scale, enabled by growth of demand. Innovation then shifts to efficient organizational forms for efficient production (exploitation), which leads to dominant designs in organization, of firms, supply chains, and market structure. This is recognized in the emergence of ‘industry recipes’ (Spender, 1989), and ‘dominant logics’ (Bettis & Prahalad, 1995) of organization. Organizational dominant designs are embodied in rule based procedures, such as ‘performance programs’ or ‘routines’.ⁱⁱ

Next, and here we begin to add to the innovation literature, this yields a platform for transferring the practice or product to novel contexts (diffusion, here called ‘generalization’), generating a ‘variety of context’. Here, there is a connection with the principle of allopatric speciation, from evolutionary theory, discussed before. By applying a practice in a novel context (niche) it is removed from the grip of established dominant designs, in product, production and distribution (in the parent niche). This yields a basis for exploration, while maintaining exploitation. In novel contexts one encounters limits of viability and usefulness, of products, production, and organization, which require adaptation, in different forms. To maintain exploitation as long as possible, these adaptations first remain close to established practice (in ‘differentiation’), with recalls from experience in earlier stages in the development of that practice. What was tried before but failed then, may be tried again, in the novel context. Next, if such incremental change fails to satisfy needs of adaptation, one observes practices, in the novel context, which appear to perform well in aspects where one’s own practice still fails. This leads to experimentation with the introduction of elements of those practices into one’s own practice, in a process of hybridization (here called ‘reciprocation’). This opens up a new ‘variety of content’. This is a crucial move, since it allows for experimentation with novel elements, thereby testing for their usefulness, while still maintaining exploitation. When useful, this puts existing architectures (Henderson & Clark, 1990) of product, production, distribution and organization under strain for several reasons, but especially because the constraints that those architectures impose prevent novel elements from realizing their full potential, which is now seen to emerge. This yields pressures to break architectures down in creative destruction, and to develop novel configurations of elements from different practices and contexts. Experience accrued from the earlier stages of generalization, differentiation and reciprocation feeds imagination, and gives indications for what elements and architectural principles to try out. In this way, experimentation with novel combinations is not blind or completely random, but there still is radical uncertainty, and much trial and error. And next we arrive back at the beginning, with a highly promising but still ambiguous and unsettled radical novelty that requires consolidation. Summing up: discovery emerges from an alternation of variety of content and variety of context. Variety of content is reduced (in consolidation), is then subjected to an opening of variety of context, which yields the basis for creating new variety of content.

The heuristic of discovery yields three points that are analytically crucial:

- It indicates how there may be continuity (intermediate steps, emergence) in the generation of discontinuity (episodic change).
- It shows why the emergence of radical novelty is slow relative to breakthroughs (punctuated equilibria).
- It shows how radical novelty may be non-random, based on learning, while still entailing much trial and error.

The different stages together make up a cycle of discovery, as illustrated in Figure 1.

Figure 1 about here

The cycle has been proposed as a general heuristic, applicable to individual learning, the development of science, innovation, market change, and organizational change. It was, in fact, inspired by the theory of the development of intelligence in children developed by Jean Piaget (1970, 1974). It may throw new light on the famous methodological debate between Popper, Kuhn, Lakatos and Feyerabend (Lakatos & Musgrave, 1976). Here, the key point is that all participants in the debate recognized that scientists do not falsify and reject their theories at the first appearance of falsifying evidence, but accumulate such misfits, in the exploration of where ‘the real limits of a theory lie’ (Popper, 1970, p. 55), before they have a basis for changing it.

The cycle may also throw a new light on the debate, in the management literature, on the conduct of multinationals, in processes of globalization. There, an important question is whether multinationals should engage in a ‘global strategy’, imposing their practices world-wide, or allow for variety, in a ‘multi-national strategy’. There are many relevant considerations here. The choice depends on economic arguments, such as the need for a uniform practice to maintain economies of scale. That, in turn, depends on technological opportunities and competitive pressures on price, and on commercial considerations, such as demand for differentiated products as a function of different circumstances of use, technical differentiability of products, or, on the contrary, market considerations to maintain a uniform product worldwide (e.g. to reduce search costs, as in the case of McDonald’s). This is not the place to reiterate the relevant literature. The point here is that even if multinationals have the power, in their offer of employment, technology, capital and access to global markets, to impose their home country practices, it may in the longer term be wiser to employ adaptation to different circumstances in different host countries, as a learning strategy (for a study of these two alternatives, in multi-national ventures in China, see Child, 2002).

One question is what drives the cycle, in particular the move towards new niches. In developmental psychology, there is a ‘principle of over-confidence’, as an instinct to apply what is successful outside the context in which it was learned, as observed in child play. This psychological drive may also play a role in the internationalization of business. In economics, there are other considerations, such as the need, for sustained growth of profits, to expand to new markets. Such may be the motives, rather than any planned effort to learn, even though in fact it leads to learning.

As noted before, the cycle represents a heuristic, rather than an inexorable logic. Its appearance, sequence of steps, and progress along the cycle, depend on many contingencies of technology and market. Radical innovation may not, or only with considerable delay, lead to consolidation in a dominant design. Several rival prototypes may compete for dominance, or on the basis of ongoing improvements an old practice may still compete, and alternatives may coexist for a long time. A well-known example of an old technology keeping up for a long time with a novel one is the prolonged existence of sailing ships next to steamships (Rosenberg, 1972). Lack of competitive incentives may lock firms into inertia, and entry- or exit barriers may block the access to novel contexts. Rather than the novel context being sought, it may be imposed, by the invasion, in home markets, of ‘competence destroying’ innovations (Tushman & Romanelli, 1985; Tushman & Anderson, 1986; Romanelli & Tushman, 1994). An example is

the inertia of publishing companies in the emergence of multi-media on the basis of the Internet, until they had to move along in exploration, on the pain of losing out completely (Gilsing, 2003).

The aim of this article now is to see if different roles and characteristics of entrepreneurship can be matched with the different stages of development, along the cycle. For this, it discusses the stages in more detail.

Consolidation

Novelty (in knowledge, technology and organization) does not spring forward ready-made and out of the blue. This happens only in the ancient Greek myth of the goddess of war and wile Pallas Athene springing fully armed from the brow of Zeus, the chief of gods. Novelty (novel concepts, practices, products, technologies) at the outset tends to be incompletely determinate. It emerges as a groping around with improvisations that need to crystallize and achieve consolidation in best practice, on the basis of experience with success and failure. It is only after consolidation that geniuses can be distinguished from fools. Radical novelty tends to be ill defined, ambiguous, and messy, with encumbrances from previous practice, and lapses back into more familiar practice. Novel ways of doing things seem to suggest themselves, but it is not clear how or why precisely they should work. This happens even in areas that appear to be quite determinate and purely deductive, such as mathematics. The mathematician Gauss once exclaimed: 'I have got my result; but I do not know yet how to get it' (Popper, 1973: 16). Repeated trials and application, supported by ancillary innovations in tools, methods, and materials, are required to find out what properly belongs to the novel practice and what not. This yields increasing efficiency from a process of narrowing down, in a reduction of variety, by elimination of what step by step is found out to be redundant, inefficient or counter-productive. This is related to what in the economic literature is known as learning by doing, and the 'experience curve': efficiency increases as a function of cumulative experience (Yelle, 1979).

In industries, the speed of the process depends on the need for standardization. In case of network externalities, for example, such pressure is great. The famous example is the race towards a technical standard for video recorders. The selection of one outcome from possible alternatives is influenced by current institutions and flukes of chance and coincidence: what happens to be around in the form of adequate materials, skills, instruments, organization, infrastructure, attitudes, habits of thought and other institutions. That is why a given technology may yield different practices in different countries or even in different organizations within an industry. Barley (1986) gives an example of how the use of electronic scanning devices was organized differently, with different results, in different hospitals. The outcome often is not predictable and may not be intended. Development may be locked into a path that later turns out to be sub-optimal or even counter-productive (Arthur, 1989; David, 1985).

The history of technology presents ample evidence of how science has often followed from the 'tinkering' or trial and error of technology, rather than leading technology. Mokyr (1990, p. 170) claimed that in the last 150 years the majority of inventions were used before people understood why they worked. This occurred in agricultural technology, mechanical machinery, metallurgy, the textile industry and shipping. However, increasingly, from the second half of the nineteenth century, scientific understanding came to feed technological development. An example is the invention of telegraphy, which required the theoretical notion of electro-magnetic waves invented by Maxwell in 1865 (Mokyr, 1990, p. 144). Chemistry also was also to a large extent guided by science. Nevertheless, the reverse order of practical tinkering preceding understanding still occurs, as has been exhibited in the information technology revolution (Dosi, 1984).

Why does consolidation take place? It results from a drive towards efficiency and standardization of operation, application and production. At first, the drive is toward feasibility, in the form a working model. After a novel technology or product gets consolidated, in an architecture of components or elements, consolidates, it gets translated into an organizational architecture for efficient production, with specialized activities for different elements. Subsequently the focus shifts from the architecture of product and organization to the optimization of elements or activities within them. The firm shapes cognitive categories around existing architectures.

The outcome of consolidation serves not only as a basis for efficient exploitation, but also as a platform for expansion and new applications, in a new 'techno-economic paradigm' (Freeman & Perez, 1989). This provides the second rationale for consolidation. This expansion, called 'generalization', provides the basis for exploration, in the accumulation of experience in different applications, as an input for learning.

In the stage of consolidation we can identify several types or aspects of entrepreneurship. First, there is a need to escape from the chaos of trial and error, to commit to a design and carry it through development, testing and entry to markets. This requires leadership and charisma to mobilize people in an uncertain and sometimes quite arbitrary looking venture, as recognized by Schumpeter. For those reasons it may be difficult to obtain outside capital, so that the entrepreneur may also have to be a capitalist, as recognized by Marshall. It requires the willingness to accept risk and tenacity to survive the inevitable setbacks, as recognized by Knight. There is also an element of arbitrage, in matching new supply to unsatisfied demand, as recognized by Cantillon and the Austrians. However, it is not adequate, in this stage of the cycle, to conceive of this in terms of given products and demand on the basis of given preferences. There is still experimentation and selection among different product forms.

As a dominant design of technology and product arises, a different kind of entrepreneurship is needed, to establish a fitting organizational architecture. As sales expand, authority and control have to be delegated, and more formalized procedures have to be designed, in a Weberian or Chandlerian type of organization. This is related to the more managerial notion of entrepreneurship, recognized by Marshall and Say. However, here management is certainly not routine. This organizational development requires a genuine kind of entrepreneurship. It entails risk and requires imagination and leadership for the development of novel forms of organization. But it is different from the earlier kind of entrepreneurship. Often, the initial entrepreneur fails to make the turnaround to this managerial type of entrepreneurship. This may result in the firm being taken over to consolidate its success.

Inertia

While consolidation is needed for efficient exploitation and for generalization, it can develop into inertia. Why this inertia? Why stick to established practice in the face of failures? Clearly, inertia can be disastrous. But directly after a novelty has settled down, and 'come into its own', one could not possibly step directly to the next novelty. Such a leap is difficult to imagine. Entrepreneurship may consist of radical jumps into the dark, with a large risk of failure and a small chance of successful radical innovation. On the aggregate level of the economy such jumps are beneficial when the weight of incidental success exceeds the weight of frequent failure. But on the level of the firm it is generally ill advised. It is counterproductive to drop and replace practices too soon, before one knows their limits and possibilities for replacement. That would lead to random drift rather than improvement (Lounamaa & March, 1987).

Kuhn (1970) not only noted, descriptively, that scientists tend to stick to the ‘puzzle solving’ of ‘normal science’, but also indicated, normatively, that a certain amount of theoretical tenacity is rational. First, there is a principle of economy: we do not and should not surrender theory at the first occurrence of a falsifier, indicating that our theory is not perfect. It is rational to wait until the cumulative weight of anomalies becomes excessive in some sense. But there is more: it is only by ongoing tests of theory that we find where its real strengths and weaknesses lie. Even Popper (1970: 55) recognized this, in spite of his drive to keep science open to criticism. We need to exhaust our theories to a sufficient extent, before we give them up, not only to recoup our investment in them, so to speak, but also to develop the motivation for a novel alternative, by an accumulation of anomalies.

This has been recognized also in the literature on organizational learning. There is a trade-off between the need to adapt and the costs involved in terms of uncertainty whether novelty will be successful, and uncertainty about the organizational repercussions (March, 1991). To make the step to novel practice one must be prepared to ‘unlearn’ (Hedberg, 1981), in the sense of no longer taking established procedures for granted. Thus a condition for innovation generally is that there is perceived need, mostly from external pressure, a threat to continued existence or a shortfall of performance below aspiration levels, as has been the dominant view in the literature on organizational learning (see the survey by Cohen & Sproull, 1996).

However, there is more, which does not seem to have been recognised in the economic and organizational literatures. While necessity may be the mother of invention, that may also need a father. Above all, we need to accumulate experience to find out what elements are eligible for preservation in the exploration of ‘novel combinations’, and what other elements and from where, to combine them with. Before we are able to replace any practice, of theory, technology or organization, we first need to pursue its potential, in a range of applications in a variety of contexts. We need this not only to build up the motive for change, in an accumulation of misfits, but also to discover where the limits of validity of an established practice lie, and to gather indications what elements to preserve from it, and how, in a novel practice. We do not know beforehand which elements are robust under changing contexts, and hence worth preserving, before we have subjected them to a variety of trials.

This is how we might combine exploitation and exploration: while employing the practice we are at the same time exploring its limits and opportunities for its change and replacement. This puts the notion of ‘inertia’ of organizations into a new perspective. Inertia is not only needed for co-ordination and control, for the sake of efficiency in exploitation. It also represents the principle of tenacity: the need to preserve existing principles in order to find out where and why they fail and how they might be replaced, as a contribution to exploration. Thus a certain amount of conservatism and inertia is rational, while it can easily become excessive and block innovation.

Generalization

Let us see how exploration is likely to proceed. If the objective is to conduct exploitation in such a way that it contributes to exploration, we should seek to do it in a way that optimizes both profit from exploitation and the gathering of the elements of discovery: motive, opportunity and means. The most straightforward way to do this is to generalize application of the practice to novel contexts. The novel context needs to be sufficiently close to afford viable exploitation and sufficiently different to yield novelty of tests and novelty of insight where limitations and opportunities for improvement lie. We see this in individual development as well as in development of firms and markets: attempts are made to carry a successful practice into neighbouring areas of application.

As in crime, the transgression of existing principles requires motive, opportunity and means. Before the need for replacement of an existing practice arises such a move would be wasteful, and before opportunity and means arise it would be impossible. First, generalization yields an opportunity for change in the escape from the sway of dominant practice, outside the 'parent niche'. Next, it yields a motive for change, from insight in the limitations of current practice. Next, it yields the means for change, in three forms. First, it yields an identification of elements of current practice that can be preserved in novel combinations, because they do not form the cause of such limitations and are persistently effective. Second, recognition of elements from other, neighbouring practices with which they can be combined with a reasonable perspective for useful and workable novelty. Third: insight in architectural principles by which these elements can be combined with a reasonable chance of success in utilizing their potential.

In economics, the contexts across which a practice is generalized may be new applications of technologies or new markets for existing products. For example: new segments in domestic markets, or foreign markets, with new conditions of demand and competition, new distribution channels, new technological conditions of production (labour, materials, components, machinery, tools), different technical infrastructures (transportation, energy, communication), and different institutions (labour markets, education and training, legal conditions, professional organizations, intermediaries, central and local government). Exploration of novel applications across contexts can to a greater or lesser extent be done virtually rather than actually, by thought experiments, scenario's, simulation of prototypes, inspection or 'reverse engineering' of practices or products used elsewhere.

In this stage of generalization we find entrepreneurship in opening up or entering new markets, as recognized by Mangoldt and Schumpeter. However, there is also an element of arbitrage: carrying products to unsatisfied demand.

Differentiation and reciprocation

As one moves to new contexts, practice needs to be differentiated to fit to them. One may need to adjust to a different availability of material inputs and tools, competencies of people, conditions of use by customers, and technical infrastructure. Here, the process of narrowing by eliminating redundancies, and the reduction of variety of practice, in the first stage of consolidation, is reversed into a process of widening into different versions and extensions of the novelty, with increasing 'variety of content'.

A proximate form of differentiation is to modify elements while preserving the architecture in which they are connected (Henderson & Clark, 1990). Next, one may re-arrange elements of an existing practice into novel architectures. For this one may tap into memory of previous applications, and experience with trials in the stage of consolidation. This is a process of problem solving, defined as seeking recourse to known ways of doing things (Holland et. al., 1989, p. 11). The potential and the success of this depend on what is available from previous experience in (organizational and personal) memory, on inventiveness in problem solving of the people involved, and on communication and co-operation between them.

A wider, more 'distant' form of structural change is to adopt elements from foreign practices encountered in the novel context, which are successful in aspects where one's own practice fails. Speculations and experiments arise concerning the adoption of elements from such neighbouring practices. It can also go the other way: elements from one's own practice are transferred to the architecture of a foreign practice. Such transfers are called 'reciprocation'.

In this stage of differentiation and reciprocation we see the entrepreneurship of crossing boundaries of accepted practice. Entrepreneurs need to convince others to join, or at least to

permit such heterodoxy. Here, the inertia of the integrated firm may take its toll. In multinationals there are battles between central office in the home country that wants to maintain coherence and company-wide standards and practices for the sake of exploitation, and host country subsidiaries that demand room for differentiation and reciprocation. The battle gets especially fierce when for the sake of novel combinations competencies are developed that are at odds with what is perceived as core competence, or alliances are sought with outside business units that are part of competing firms. While the entrepreneur in the stage of consolidation is primarily a socializer, here he needs to be a diplomat. Lack of acceptance may impel him to leave the firm and start up for himself. Here, the entrepreneur is the rebel and maladapted loner (Schumpeter, Kets de Vries).

There is also an entrepreneurial challenge at the level of top management. The paradoxical challenge is to combine the preservation of structures for exploitation with an allowance for deviations for the sake of experimentation. The difficulty of this depends on how 'systemic' versus 'stand-alone' the architecture for exploitation is (Langlois, 1998). When highly systemic, the system has many densely connected elements, with narrow tolerances in interfaces. Here, deviations in elements, for the sake of experimentation, would entail wide repercussions for adaptation in other elements of the system. An example is a refinery. Then, there is a high cost, while the promise of results is highly uncertain. On the other hand, in stand-alone systems elements are highly autonomous in their exploitation. If, in addition, exploitation itself already requires highly differentiated products for different customers, there is more scope to combine exploitation and exploration. An example is a consultancy firm. An intermediate case is that of a modular system, where elements are many and mutually connected but self-contained and replaceable, provided that they satisfy the constraints in the system. There is genuine entrepreneurship in these issues of organizational design, to balance exploitation and exploration. There is a range of options for such design, but it would go too far to discuss them here (see Nooteboom, 2000). This entrepreneurial task can, perhaps, be seen as of the 'managerial' type (Marshall), but it goes beyond any simple, optimal matching of production factors, according to a given 'production function'.

In case exploration cannot be allowed within the system, one may locate exploration outside it, or at the periphery of the organization. An example is the 'skunk works' of 3M company, where entrepreneurial units are allowed to go their own way, outside the established order of structures, procedures, rules, guiding concepts, and established meanings. However, then the question arises what sense it makes to maintain them within the organization at all. An alternative then lies in 'external corporate venturing', where the firm facilitates headstrong entrepreneurial types to spin off their own ventures. For this, the firm may act as a venture capitalist, and may offer a guarantee of return to the firm in case of failure. By having a stake in the capital of the venture, the firm may hedge its bets and keep the option open of integrating the outcome after proven success, when it is clearer what the potential revenues and repercussions in upsetting established organizational structure would be. In case of too much lack of fit even then, the firm may sell its share. Here, the firm adopts the entrepreneurial role of a venture capitalist. A problem here might be that the firm uses its stake to put the innovation on hold, in case it yields products that cannibalise existing products that the firm wants to maintain.

Radical innovation

Recombination of elements from different practices in novel architectures can lead to 'accommodation' in the form of 'novel combinations' (Schumpeter), yielding 'radical' or 'large' or 'macro' innovations. Often this is 'competence destroying' for incumbent organizations, and outsiders may be needed to make the break.

A radically novel combination is not easy to identify as an opportunity, since it literally does not make sense; it cannot be interpreted in terms of existing practices, and therefore extends beyond established meanings and corresponding categories. It has no recognizable identity. It requires a leap of imagination. That is why it is more of a lonely, personal affair: it is difficult to have the hunch make sense even to oneself, let alone others. A handful of people stumbled upon X-rays, but only Madame Curie saw what it might mean, and what its implications and uses might be. The role of chance increases: we are in the field of serendipity, but it is the serendipity of the prepared mind. This yields the 'King Saul effect' (Mokyr, 1990, p. 286). Looking for a better dynamo for bicycle lights, Philips Company hit upon the development of an electric shaver. Gasoline at first was a useless by-product in the derivation of lubricants from crude oil, before it was developed into a fuel for the internal combustion motor. Bessemer invented his steel making process while trying to solve problems of a spinning cannon shell (Mokyr, 1990, p. 116).

How, then, do radically novel combinations arise, in new architectures of elements from a variety of previously unconnected practices? Problems accumulate in the preceding process of reciprocation, in hybrid structures of elements form different architectures. Ad hoc additions and modifications mess up the clarity, consistency and efficiency of the practice, and increase complexity, resulting in loss of efficiency and diminishing returns: it becomes increasingly difficult to make further additions or modifications while maintaining coherence. Elements are duplicated, in different parts of the architecture, with foregone opportunities for economy of scale. Unsolved failures to perform are accumulated. This provides an incentive to consider a clean-up by dropping rather than by only re-arranging elements, in novel architectures. Above all: existing architecture imposes limits on the novel elements brought in, preventing realization of their true potential. Thus pressures build up to break down the architecture to realize the potential of novelty. Experience has accumulated to suggest which novel combinations of elements, gathered in reciprocation from a variety of old practices, might be successfully combined, and by which architectural principles. There is a basis for reasonable hunches. Here, in the imagination and trial of novel combinations the Schumpeterian entrepreneur comes into his own. And when success in novel architectures emerges we are back at the beginning, with a need for consolidation.

Conclusion

According to the cycle of discovery, without innovations of application (in differentiation, reciprocation) creative destruction (novel combinations) would not take place. Diffusion does not consist in a simple mechanical 'working out' of a single innovation. Generally, new contexts or new applications require adjustment or 're-invention'. Is this secondary innovation Schumpeterian or Kirznerian? The whole notion of equilibrium, and the distinction between equilibrating (Kirznerian) and dis-equilibrating (Schumpeterian) entrepreneurship becomes problematic. The point of the cycle is that in the combination of exploitation and exploration, in consolidation, generalization, differentiation, reciprocation, and novel combinations in novel architectures, diffusion lays the basis for the next innovation. What is supposed to be equilibrating at the same time is dis-equilibrating in the sense that it prepares for the next innovation. Entrepreneurship can be seen in both the creation and the realization of potential. The cycle of discovery entails that the realization of potential lays the basis for new creation of potential.

The stages of consolidation and generalization, with their shift to more systemic integration, increase of scale, division of labour and co-ordination would connect with Say's and Marshall's notions of entrepreneurship. Generalization entails the transfer to novel areas of

application. For products this entails the entry into new markets. This reflects Mangoldt's notion of entrepreneurship, and was recognized also by Schumpeter. In differentiation practices are adapted to differences in demand. This may connect with the arbitrage notion of entrepreneurship. However, while it entails the realization of existing potential, it also entails learning and conceptual change, leading up to a next innovation. Reciprocation is more Schumpeterian in that it explores elements for novel combinations. Schumpeterian entrepreneurship comes more into its own in accommodation towards novel combinations in novel architectures, where existing structures of action are broken down and from the debris novel practices are experimentally built up, to survive, die or be improved in the subsequent stage of consolidation.

In sum, up to a point we can locate existing notions of entrepreneurship in different stages, along the cycle of discovery, as illustrated in Figure 2.

Figure 2 about here

However, there are ambiguities in the attempt to fit existing notions of entrepreneurship along the cycle. How far does the arbitrage notion of entrepreneurship (Smith, Cantillon Austrians) go? To what extent does it include adaptation in the form of differentiation and reciprocation? Does it overlap, and where, with Schumpeterian entrepreneurship? In reciprocation, perhaps? Perhaps this matching exercise becomes too forced. Perhaps the analysis serves to show that the distinctions and boundaries between old notions are unclear. Perhaps the analysis should be seen as going beyond old notions of entrepreneurship, to provide new perspectives and aspects of entrepreneurship, as follows.

In consolidation we find:

- Recognition of success and failure. This requires sense of realism, in the judgement of technical and commercial viability.
- Adapting or innovating systems of application to allow the innovation to achieve its fullest potential. This requires managerial innovation and corresponding capabilities, for utilization of economies of scale and scope, in division of labour, and corresponding standardization and development of organizational structure and procedures for coordination.

In generalization:

- Risk taking and vision for expansion into new applications and markets, and design of corresponding systems of coordination.

In differentiation:

- Incremental innovation by adaptation of practices to new conditions of demand and production, while maintaining the basic elements and architecture of existing practice. This requires 'intrapreneurship', with perceptiveness, imagination, the courage to use it and accept the risks involved.
- On the level of top management it requires the ability to combine the maintenance of efficient exploitation with an allowance for local deviations, in requisite forms of decentralization.

In reciprocation:

- Importation of elements from 'adjacent' practices that in novel contexts appear to be better in some respect of product or production, while maintaining the architecture of the practice at hand. The requirements from the previous stage apply to a higher degree:

imagination to produce ideas for novel combinations. The intrapreneur requires an ability of diplomacy to obtain scope for experimentation while still adhering to demands for coherence with existing practices.

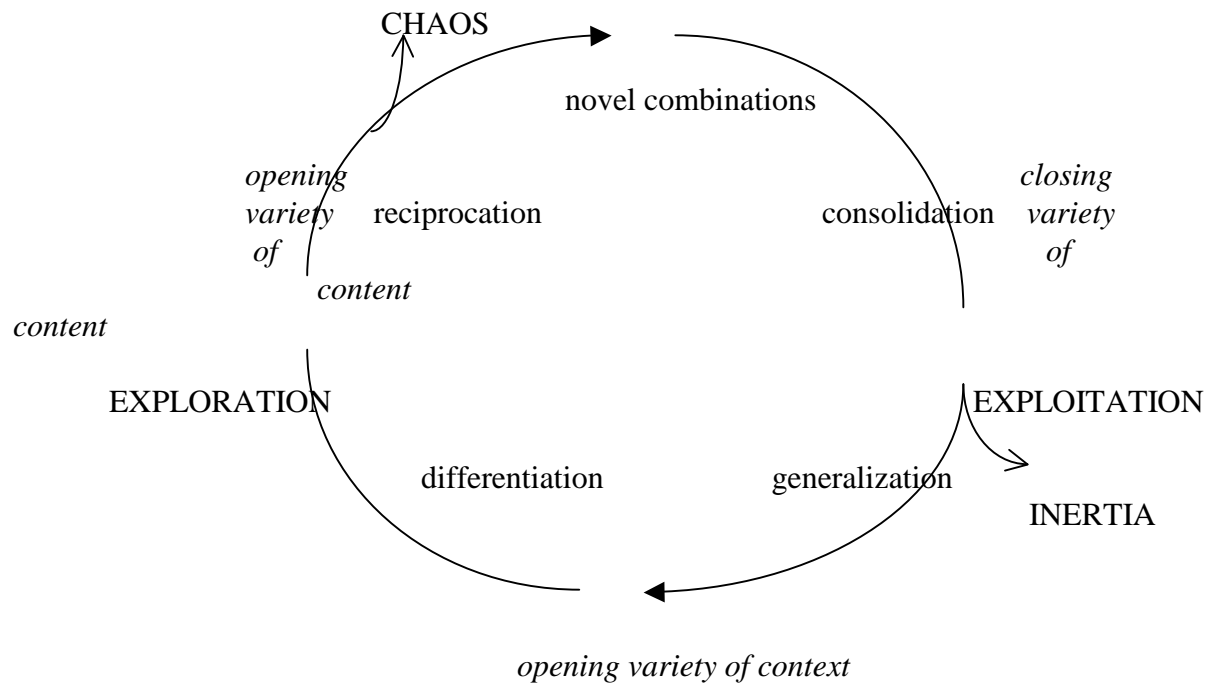
- On the level of top management, the problem of combining efficient exploitation and local deviations, for the sake of exploration, becomes more problematic. Patterns of collaboration are required with outside firms, typically in joint ventures. This requires skills of cross-cultural management.

In radical novel combinations:

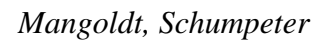
- Trials of new combinations of elements from diverse practices in a new architecture. This requires a high degree of risk acceptance, courage, determination, perseverance and charisma and leadership to bring other people along, including internal or external suppliers of capital.
- This stage requires a large degree of organizational autonomy. If the origin of ideas lay inside a large, integrated organization, this will often require a spin-off, particularly when the existing system of exploitation is highly systemic. Top management may then need to be entrepreneurial in the sense of facilitating external corporate venturing.

Clearly, along the cycle, the requirements of entrepreneurship vary greatly, and require different people with different competencies. For example, while radical innovation requires courage, independence, boldness and determination to tenaciously pursue an idea, consolidation requires a sense of realism, in the recognition of failure, and the ability to step back and design structures of coordination and seek compromise between conflicting interests . Few people will be able to combine such competencies.

Figure 1: cycle of discovery



Schumpeter, Thünen



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ⁱ The term ‘discovery’ has the connotation of literally removing the cover from something that already exists. I do not intend that meaning here. Here, discovery is synonymous with ‘invention’, but I don’t use that term because it is too much associated with technological invention, while I want to denote the emergence of new technology, organization and knowledge generally.

ⁱⁱ In cognitive science we encounter ‘paradigms’ (in the sense of exemplars to be emulated), ‘mental models’ (Johnson-Laird, 1983), ‘scripts’ (Abelson, 1976; Shank & Abelson, 1977), mental ‘prototypes’ (Rosch, 1977) and ‘stereotypes’ (Putnam, 1975). Across all these fields of technology, organization, knowledge and language we see the notion of novelty becoming consolidated in a standard practice, which provides the basis for efficient exploitation.